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Original article

Rescue surgical pulmonary embolectomy for acute massive pulmonary embolism

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Abstract

Background: Acute massive pulmonary embolism is a life threatening emergency that is associated with high mortality rate. Patients presenting with cardiac arrest could be saved by emergency pulmonary embolectomy.

Patients and Methods: Here we present king Abdulaziz University Hospital [KAUH] experience of 5 cases of massive and one case of submassive pulmonary embolism not amenable to thrombolytic therapy treated in our hospital within 18 month period from May 2012 to October 2013. All patients with massive pulmonary embolism were hemodynamically unstable. Three patients had cardiac arrest related to surgical procedures: one during liposuction, another during fixation of a fracture, and the third 2 h after cesarean section. Emergency pulmonary embolectomy was performed for all.

Results: We had 2 cases of mortality (33.3%). One died intraoperatively and the other died 15 days postoperatively from complications of thrombosed inferior vena cava IVC filter. Two patients of survivors developed acute renal failure postoperatively and required dialysis. They improved and were discharged in stable condition.

Conclusion: Surgical pulmonary embolectomy is a rescue operation in high-risk PE. It could save patients with preoperative cardiac arrest. Early diagnosis, interdisciplinary team action, appropriate and emergent treatment strategy are necessary for favorable outcome.

Keywords: Massive pulmonary embolism; Surgical pulmonary embolectomy

1. Introduction

Despite advances in diagnostic and therapeutic modalities, pulmonary embolism (PE) is still associated with significant morbidity and mortality [1]. Acute severe pulmonary embolism is a life threatening condition that mandates rapid intervention to restore pulmonary blood flow and stabilize hemodynamic state. Thrombolytic therapy is

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widely used as a first line treatment with satisfactory results. Catheter embolectomy had been introduced as a minimal invasive technique while surgical embolectomy was traditionally reserved to salvage patients with circulatory collapse or used when thrombolytic therapy is contraindicated or had failed [2]. Nowadays, indications of surgical embolectomy have extended to include hemodynamically stable patients with submassive pulmonary embolism and right ventricular dysfunction [3]. The aim of our work is to focus on the role of surgical embolectomy to rescue critically ill patients with massive pulmonary embolism and review literature for outcome.

2. Patients and Methods

2.1. Case 1

A 46-years-old female admitted electively for liposuction and fat graft injection. She was healthy with no medical illness. During the procedure, after about 4 h of recumbency on her back, the patient desaturated, her blood pressure dropped and had cardiac arrest. She was resuscitated and recovered with profound hypotension despite use of high inotropic support. Anesthetists did TEE, they documented dilated & poor function of right ventricle so massive pulmonary thromboembolism was suggested. Cardiac surgery team was consulted, and the decision was to go for salvage pulmonary embolectomy. Sternotomy was done while cardiac massage was going on. Cardiopulmonary bypass was initiated emergently. Pulmonary artery was opened after inflow occlusion by snaring the SVC and the IVC. No thrombotic emboli were found. The pulmonary artery was irrigated and suctioned using copious amounts of heparinized saline and manual bilateral lung massage. All trials of weaning from cardiopulmonary bypass failed despite use of maximal pharmacological and mechanical support including intra aortic balloon pump. A presumptive diagnosis of fat embolism, as the cause of death, was made.

2.2. Case 2

A 28-years-old female, obese, with no comorbids twisted her ankle while waking up from bed. She developed fracture of left distal tibia that was put in a cast for two weeks. Thereafter she was referred to our hospital for open reduction internal fixation (ORIF). Fixation was done under general anesthesia in prone position. A well padded pneumatic tourniquet was placed around the thigh and inflated for 2 h. At the end of procedure the tourniquet was removed. At this point the patient desaturated, became hypotensive and had cardiac arrest. CPR was started and the heart recovered sluggishly on high inotropic support. Massive PE was thought so cardiac surgery team was consulted. The decision was to go for rescue pulmonary embolectomy. Large amounts of emboli were filling the main, right and left pulmonary arteries and were extracted using forceps, suctioning, irrigation and bilateral pulmonary compressions. Patient was weaned from cardiopulmonary bypass on high inotropic support. Because of severe pulmonary hypertension, right ventricular distension and dysfunction we kept the chest opened and closed it in the 4th POD. Postoperatively, the patient developed acute renal failure that required dialysis. IVC filter was inserted 3 week later. Renal functions gradually recovered and the patient was discharged home in the 50th day post op for clinic follow up.

2.3. Case 3

A 17-years-old male, a known case of ulcerative colitis, recurrent bilateral lower limb DVT and on warfarin, stopped 20 days back came to ER with chest pain and shortness of breath. He was hypotensive and desaturated. CT chest was done and showed massive PE (Fig. 1). Cardiac surgery team was consulted for emergency pulmonary embolectomy as thrombolytic therapy was contraindicated because of the ulcerative colitis. After opening the pulmonary artery, large clots were extracted from main, right and left pulmonary arteries. Suction irrigation and lung compressions helped removal of clots. Weaning from pump was achieved on minimal dose of inotropes. He tolerated closing the sternum. The patient was shifted to surgical intensive care unit (SICU) in stable condition, Anticoagulation was started 6 h post op. Early postoperative course was uneventful. The patient was weaned from mechanical ventilation (MV) and inotropes and started physiotherapy. IVC filter was inserted 6 days after surgery. Three days later he became tachypnic, tachycardic and hypotensive with progression of the lower limb edema, discolouration, erythema and ecchymosis. Mechanical ventilation and inotropes were resumed. A full-blown picture of venous gangrene developed causing septic shock. He had renal shutdown and Continuous Veno-Venous Hemofiltration (CVVH) was

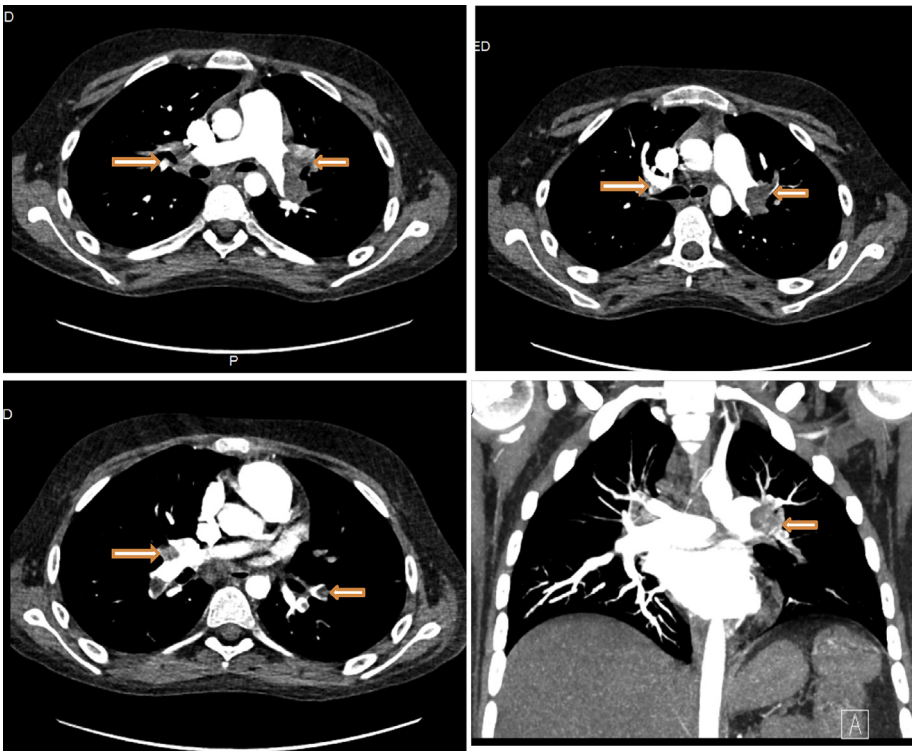

Fig. 1. CT pulmonary angiography showing multiple emboli in the main & distal branches of pulmonary artery.

started. Vascular, haematology, orthopedic and general surgery physicians were consulted. Four days later he had multiorgan failure and DIC. He died in the 15 days post op.

2.4. Case 4

A 69-years-old male patient came to ER with shortness of breath (SOB) and chest pain. He was conscious, tachypneic, and hypotensive. CT chest showed large right atrial thrombi and massive pulmonary emboli filling the main, right and left pulmonary arteries (Fig. 2). All thrombi and emboli were successfully removed. The patient was weaned from pump on high inotropes and the sternum could not be closed because of cardiac edema and right ventricular dysfunction. The postoperative course was complicated by acute renal failure that necessitated dialysis. In 23th POD, renal function recovered and he was discharge in 49th POD.

2.5. Case 5

A 23-year-old female underwent elective caesarian section. Two hours postoperatively, she suddenly developed cardiac arrested. CPR was started and she revived. Since there was no apparent cause for that, massive PE was suspected. She was emergently shifted to OR for salvage pulmonary embolectomy. Extraction of emboli blocking main and both pulmonary arteries down to lobar branches was performed. Weaning from pump was difficult. Her abdomen was gradually distending. Intra abdominal bleeding was expected. Caesarian wound was opened and blood was filling the peritoneal cavity. Search for source revealed ruptured hepatic subcapsular hematoma most likely caused by cardiac compressions during CPR massage. Suctioning of the blood, saline irrigation and use of topical haemostatic agents controlled the bleeding. The abdomen was closed and the chest was left open and closed after 2 days. The patient required mechanical ventilation for 2 weeks. She improved and discharged on warfarin.

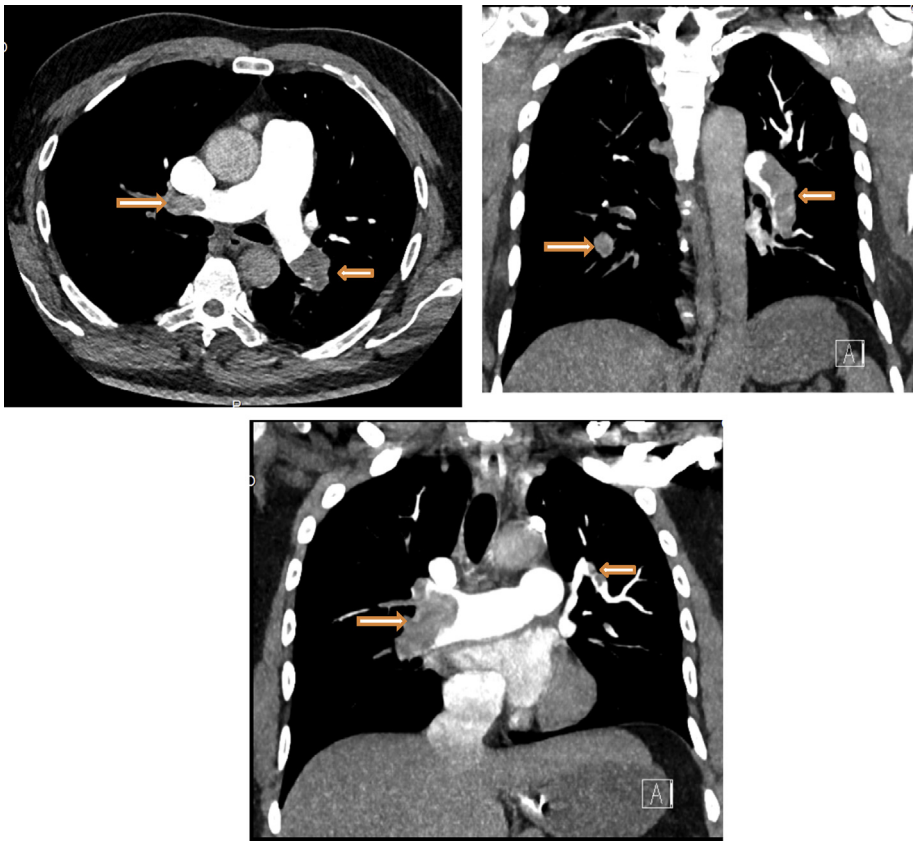

Fig. 2. CT pulmonary angiography showing multiple emboli in the main & distal branches of pulmonary artery.

2.6. Case 6

A 45-years-healthy male presented with sudden SOB. Transthoracic echocardiography revealed right atrial thrombus. In addition, large thrombus was found nearly occluding the left pulmonary artery as shown by CT pulmonary angiography. He was hemodynamically hypotensive & tachycardiac. Urgent pulmonary embolectomy and removal of RA thrombus were done. Histopathological examination confirmed the diagnosis and ruled out the possibility of myxoma. The postoperative course was uneventful. He was discharged on oral anticoagulant.

2.7. Surgical technique

In all of our cases median sternotomy was the standard incision. Cardiopulmonary bypass was conducted by aortic and bicaval cannulation. We did not clamp the aorta and heart was kept beating under normothermic condition. Pulmonary artery was opened by longitudinal incision after inflow occlusion by snaring the SVC and the IVC. Under direct vision, thrombi were removed by forceps. No additional incisions were needed to remove thrombi from main pulmonary arteries. Gentle compression of lungs facilitated retrieval of thrombi from distal pulmonary branches. We did not use Fogarty catheter to avoid injury to pulmonary arteries. If sternal closure compromised hemodynamic state we kept the chest opened.

3. Results

We had 2 cases of mortality (33.3%). One died intraoperatively and the other died 15 days postoperatively from complications of thrombosed inferior vena cava IVC filter. Two patients of survivors developed acute renal failure postoperatively and required dialysis. They improved and were discharged in stable condition.

Characteristics and outcomes of patients are collectively summarized in Table 1.

Table 1
Characteristics and outcomes of patients.

Patient	Age	Sex	Risk factors	Cardiac arrest	Diagnosis	Complication	Survival
1	46	F	Obesity, liposuction	Yes	Clinical &ECHO	NO	NO
2	28	F	Obesity, Immobility, bone fixation	Yes	Clinical	RF	YES
3	17	M	UC, DVT	No	CT angio	IVC filter thrombosis, RF, DIC	NO
4	69	M	NO	No	CT angio	RF	YES
5	23	F	Pregnancy	Yes	Clinical	prolonged MV	YES
6	45	M	NO	No	ECHO, CT angio	NO	YES

F: female, M: male, UC: ulcerative colitis, DVT: deep venous thrombosis, RF: right ventricular failure, DIC: disseminated intravascular coagulopathy, MV: mechanical ventilation.

4. Discussion

PE still presents a challenge and is associated with significant morbidity and mortality. Massive PE is a life threatening condition that requires early diagnosis and aggressive management. The International Cooperative Pulmonary Embolism Registry (ICOPER) studied 2452 patients from 52 centers and reported an incidence 4.5% of massive PE among all PEs with high mortality rate of 52.4% at 90 days [4]. The pathophysiology of massive PE includes mechanical obstruction together with hypoxic vasoconstriction of pulmonary vasculature. This will ultimately increase RV afterload leading to RV failure. European Society of Cardiology (ESC) in their guidelines on diagnosis and management of PE in 2014 used the term high-risk acute PE instead of massive PE. High-risk PE is defined as acute PE with shock or hypotension (systolic blood pressure < 90 mm Hg or a systolic pressure drop by ≥40 mm Hg, for >15 min not due to other causes e.g. arrhythmias, hypovolemia, or sepsis) [5]. CT pulmonary angiography is the gold standard diagnostic modality for suspected PE. It allows visualization of pulmonary vasculature down to segmental level [6]. We relied on it for diagnosing cases No. 3, 4, and 6. However, the remaining 3 patients had cardiac arrest and underwent prolonged CPR even continued in OR (case No. 1). There was no time for any investigation. Those patients did not have any associated comorbids and no apparent cause to explain cardiac arrest other than acute massive PE especially they were at risk for that (obesity in all, pregnancy in case 5, immobility in case 2 and prolonged operation and liposuction in case 1). We decided to salvage those patients by emergency embolectomy since this was the only hope. Two patients (case 2 and 5) were hopefully saved. We believe this practice is justified and we reported this opinion [7]. This is in accordance to Digonnet et al. [3] and Leacche et al. [8] who operated patients after cardiac arrest based entirely on clinical suspicion. In case 1, no thrombus was found and fat embolism was likely the cause of cardiac arrest. The pathophysiology of fat embolism involves both mechanical obstruction of pulmonary capillary vasculature and inflammatory effects [9]. The latter was most probably the involved mechanism in our case and the site of embolism might be in distal pulmonary vasculature. Our center does not have the authority of postmortem diagnosis. Traditionally, surgical pulmonary embolectomy was reserved for patients with cardiogenic shock or used when thrombolytic therapy is contraindicated or had failed. However, indications of surgical embolectomy had recently been liberalized to include group of patients who are hemodynamically stable. In ESC guidelines surgical embolectomy is indicated for high-risk PE (Class I; level of evidence C) and for selected cases of intermediate-high-risk when thrombolysis is contraindicated or failed (Class IIb; Level of evidence C). Patients with right atrial thrombi straddling through patent foramen ovale are also candidate for surgery. Percutaneous catheter directed treatment is an alternative to surgery (class IIa; level of evidence C). This is decided by interdisciplinary team involving a cardiac surgeon and an interventional cardiologist [5]. All of patients except case 6 belonged to the group of acute high-risk PE. Early series of surgical embolectomy reported high mortality between 20% and 30% [10]. This could be explained by the critical preoperative hemodynamic state of patients being operated after cardiogenic shock or even cardiac arrest. There is a growing evidence that preoperative hemodynamic derangement is an independent risk factors for operative mortality [11]. Mortality of patients with preoperative cardiac arrest reaches 59% and even 70% in some series [12,13]. Ullmann et al. found that patients brought to OR with continuous CPR had a higher mortality rate than those intermittently resuscitated and brought with stable hemodynamics (80% vs 40% respectively) [11]. Early surgical intervention is of crucial importance and could reduce mortality by 40% if performed in the first 24 h of events [14]. Thrombolytic therapy for patients with massive PE and

hemodynamic compromise has a higher mortality rate, risk of major hemorrhage and recurrence when compared to surgical embolectomy [15].

The increasing awareness of our colleagues about the role of surgical embolectomy as a life saving maneuver for high-risk PE helped reach rapid diagnosis and referral to all time available cardiac surgery team. Although we operated our patients emergently without delay, the critical unstable preoperative hemodynamic state adversely affected our results (mortality of 33.3%). Samoukovic et al. reviewed literature from 1968 to 2008 regarding role of embolectomy in acute PE and found that cumulative surgical mortality substantially decreased over time from 35% to 19% [16]. This conclusion was also supported by Stein et al. [10] in his review of 1300 cases of pulmonary embolectomy collected from 46 reports from 1961 to 2006. This improving outcome could be explained by expanding indications of pulmonary embolectomy to include hemodynamically stable patients with RV dysfunction, earlier diagnosis and intervention before cardiac arrest and improved surgical techniques [17]. Digonnet et al. studied 21 patients who underwent surgical embolectomy. Fourteen of them had massive PE and the remaining patients had submassive PE. Mortality was 57% among the first group while all patients with submassive PE were saved. In their series, surgical embolectomy saved 33% of patients previously resuscitated by CPR ($n = 6$). They recommended surgical embolectomy for massive as well as submassive PE as a primary treatment modality [3]. This was recommended by Leacche et al. who liberalized indications of surgical embolectomy to include hemodynamically stable patients with large central clots and RV dysfunction [8]. We started to follow this strategy and the outcome of case No. 6 was uneventful. A recent large study carried out by Neely et al. included 115 patients who underwent surgical pulmonary embolectomy for central PE. Forty nine (43%) were hemodynamically unstable and 56 (49%) were stable. The overall mortality was 6.6%: unstable 10.2% versus stable 3.6% ($p = 0.247$). Three-year survival rate was 65.8% and 80.4% for unstable and stable group respectively [18]. In patients who are hemodynamically unstable or those with cardiac arrest, veno-arterial extracorporeal membrane oxygenation (VA ECMO) could be used to support cardiac and respiratory status till embolectomy is performed [19]. A series of emergency pulmonary embolectomy carried out by Takahashi et al. for 24 patients with high-risk acute PE showed 12.5% in-hospital mortality. They operated patients with poor preoperative state. Nineteen (79.2%) patients were in cardiogenic shock and 11 (45.8%) patients were in cardiac arrest. preoperative percutaneous cardiopulmonary support which was inserted in 16 (66.7%) patients had improved the outcome and the 5-year cumulative survival rate was 87.5% ± 6.8% [20,21]. Patients with massive PE have severe RV dysfunction and we believe it may be necessary to keep the chest opened if closure trial compromises the hemodynamic state. We applied this for 2 of our patients. The unstable hemodynamic state is a risk factor for postoperative acute renal failure. Proper timing of dialysis is necessary. Two of our patients underwent early dialysis and recovered. Venous filters are indicated for patients with absolute contraindications for anticoagulants and for recurrent PE [5]. Caval thrombosis is a serious complication of venous filters and can cause edema of lower extremity and phlegmasia cerulea dolens. This is greatly affected by the conditions predisposing the patient to thromboembolism [20,21]. Case 3 unfortunately had this complication. This patient had inherited coagulation disturbance.

4.1. Limitations

Our present study has some limitations. It is a retrospective, nonrandomized study. Few number of cases were included. Actually pulmonary embolectomy is an uncommon procedure in most centers. This study could contribute to review of literature and expand knowledge about this issue. Clinical scenarios of our cases highlight the importance of interdisciplinary team management, rapid decision making and role of surgical embolectomy as a life saving modality.

5. Conclusion

Surgical pulmonary embolectomy is a rescue operation in high-risk PE. It could save patients with peroperative cardiac arrest. Early diagnosis, interdisciplinary team action, appropriate and emergent treatment strategy are necessary for favorable outcome.

Conflict of interest

None.

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